PROGRAM facts

U.S. DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

Strategic Center for Natural Gas and Oil

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OIL EXPLORATION & PRODUCTION PROGRAM ENHANCED OIL RECOVERY

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Background

Conventional primary and secondary recovery operations often leave two thirds of the oil in the reservoir. In the U.S., enhanced oil recovery (EOR) methods have the potential to recover an estimated 200 billion barrels of the remaining discovered oil resource. Without EOR, much of this oil will be left in the ground. Although often highly effective, EOR methods are more expensive production methods; consequently, during times of low oil prices their application is limited. However, with an emerging consensus for continued high oil prices and growing concerns over America's energy security, interest is being revitalized in EOR technologies for increasing recovery.

EOR processes involve injecting a gas or fluid into the reservoir to increase reservoir pressure or reduce oil viscosity in order to mobilize the oil. Injectants include steam (thermal processes); polymers and gels (chemical processes); carbon dioxide, nitrogen, and natural gas (gas processes). A fourth process is microbial EOR.

In 2003, thermal recovery projects produced 52% of the total oil produced from EOR methods in the U.S., CO_2 projects produced 31%, and other gas injection and chemical methods produced the remaining 17%.

CO_2 recovery is particularly attractive because it not only is effective in increasing oil recovery, it also can be a way to sequester the CO_2 generated by power plants and other industries, thereby reducing greenhouse gas emissions.

Description

The goal of the EOR Program is to develop technologies to more efficiently recover petroleum from known reservoirs not producible by current technology, reduce the rate of well abandonments, and improve reservoir modeling and process prediction techniques.

The EOR Program focuses on the development and deployment of technologies that increase oil recovery efficiency in domestic mature reservoirs, in order to produce oil not producible by primary or secondary recovery.

The program areas include:

- CO_2 injection, which increases production by raising reservoir pressure and reducing oil viscosity.
- Thermal methods that are used to recover heavy oil where heat is used to lower oil viscosity
- Chemical methods that consist of injecting 1) polymers and gels to control movement of water and oil in the reservoir; 2) surfactants, or alkaline-enhanced chemicals that release the oil from the reservoir rock surfaces; and 3) foams to displace oil from the reservoir to the producing well.

ADDRESSES

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- Microbial EOR, where either microorganisms are injected into the reservoir or the in-situ bacteria are encourage to grow, producing gas and surfactants to improve oil recovery.

- Novel Methods, which are those outside the mainstream of EOR technology. One current novel method employs seismic vibrations to change the reservoir's fluid properties.

- Reservoir Simulation, which entails developing advanced computational techniques to help predict the response of a reservoir to a current recovery process or to predict the oil recovery of a planned project.

Accomplishments

The EOR program has produced a number of key accomplishments in basic and applied EOR research. It pioneered the development of non-proprietary field demonstrations of steam, chemical, and CO_2 flooding in the mid-1970s. A 2001 National Research Council (NRC) report assessing the success of DOE's oil and gas R&D programs concluded that lessons learned from these early field demonstrations "in terms of direct benefits was critical to a changed view of reservoirs and fluids behavior." This in turn led to a more research-focused effort in the EOR program to improve understanding of complex reservoirs for effective deployment of EOR methods. Such efforts included the first non-proprietary EOR reservoir simulators.

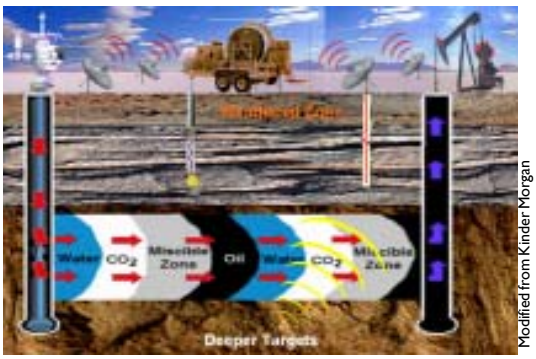
The NRC report cited among the EOR program's "notable R&D accomplishments advancements in the understanding and control of of CO_2-based EOR, especially development of chemicals and foams for mobility control; fundamental research on the miscibility of multicomponent systems; new technologies for thermal-based EOR; and the introduction of microbial EOR."

Benefits

DOE estimates that its EOR program and related technologies have yielded output of about 167 million barrels of oil equivalent more than would have been produced by industry alone. EOR currently accounts for about 12% of total U.S. oil production, and DOE directly credits its EOR program for about 2.8% of the U.S. EOR total.

During 1978-2000, the EOR program spent $177 million and drew $47 million in cost sharing, in 1999 dollars. The return on this investment, according to the 2001 NRC report, was $625 million in cost savings to producers. When added federal estate revenues are included, that total jumps to about $700 million, according the NRC report.

The NRC report singled out the EOR program as one of the two fossil energy R&D programs that have "increased oil production and reserve additions in the United States and thereby reduced U.S. dependence on imported oil."



Subsurface view of a CO_2 WAG (water-alternating-gas) flood.